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Risø National Laboratory, DK-4000 Roskilde, Denmark
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ENVIRONMENTAL RADIOACTIVITY IN GREENLAND IN 1981

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Abstract. Measurements of fallout radioactivity in Greenland in 1981 are reported. Strontium-90 (and Cesium-137 in most cases) was determined in samples of precipitation, sea water, vegetation, animals, and drinking water. Estimates are given of the mean contents of ^{90}Sr and ^{137}Cs in the human diet in Greenland in 1981. Further results of the $^{239,240}Pu$ and ^{241}Am measurements on samples from the expedition to Thule in August 1979 are presented. Brown algae collected in East Greenland in 1969 were analysed for Pu and Am.

INIS Descriptors

[0] DEER, DIET, ENVIRONMENT, EXPERIMENTAL DATA, FISHES, FOOD CHAINS, GLOBAL FALLOUT, GRAPHS, GREENLAND, PLANTS, RADIOACTIVITY, SEAWATER, SHEEP, TABLES
[1] ATMOSPHERIC PRECIPITATIONS, DRINKING WATER, STRONTIUM 90
[2] CESIUM 137
[3] ALGAE, AMERICIUM 241, PLUTONIUM 239, PLUTONIUM 240, SEDIMENTS

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CONTENTS

ABBREVIATIONS AND UNITS

J: joule: the unit of energy; 1 J = 1 Nm (= 0.239 cal)
Gy: gray: the unit of absorbed dose = 1 J kg^{-1} (= 100 rad)
Sv: sievert: the unit of dose equivalent = 1 J kg^{-1} (= 100 rem)
Bq: becquerel: the unit of radioactivity = 1 s^{-1} (= 27 pCi)

cal: calorie = 4.186 J
rad: 0.01 Gy
rem: 0.01 Sv
Ci: curie: $3.7 \cdot 10^{10}$ Bq (= $2.22 \cdot 10^{12}$ dpm)

T: tera: 10^{12}
G: giga: 10^{9}
M: mega: 10^{6}
m: milli: 10^{-3}
μ: mikro: 10^{-6}
n: nano: 10^{-9}
p: pico: 10^{-12}
f: femto: 10^{-15}
a: atto: 10^{-18}

cap: caput: (per individual)
TNT: trinitrotoluol; 1 Mt TNT: nuclear explosives equivalent to 10^{9} kg TNT.

cpm: counts per minute
dpm: disintegrations per minute
OR: observed ratio
CF: concentration factor
FP: fission products
μR: micro-roentgen, 10^{-6} roentgen
S.U.: pCi ^{90}Sr (g Ca)$^{-1}$
O.R.: observed ratio
M.U.: pCi ^{137}Cs (g K)$^{-1}$

V: vertebrae
m: male
f: female
nSr: natural (stable) Sr

eqv. mg KCl: equivalents mg KCl: activity as from 1 mg KCl (~ 0.88 dpm)

S.D.: standard deviation: $\sqrt{\frac{\Sigma(\bar{x}-x_i)^2}{(n-1)}}$

S.E.: standard error: $\sqrt{\frac{\Sigma(\bar{x}-x_j)^2}{n(n-1)}}$

U.C.L.: upper control level
L.C.L.: lower control level
S.S.D.: sum of squares of deviation: $\Sigma(\bar{x}-x_i)^2$
f: degrees of freedom
s^2: variance
v^2: ratio between the variance in question and the residual varian e
P: probability fractile of the distribution in question
η: coefficient of variation, relative standard deviation
ANOVA: analysis of variance
A: relative standard deviation 20-33%
B: relative standard deviation >33%, such results are not considered significantly different from zero activity
B.D.L.: below detection limit

In the significance test the following symbols were used:
* : probably significant (P > 95%)
** : significant (P > 99%)
***: highly significant (P > 99.9%)

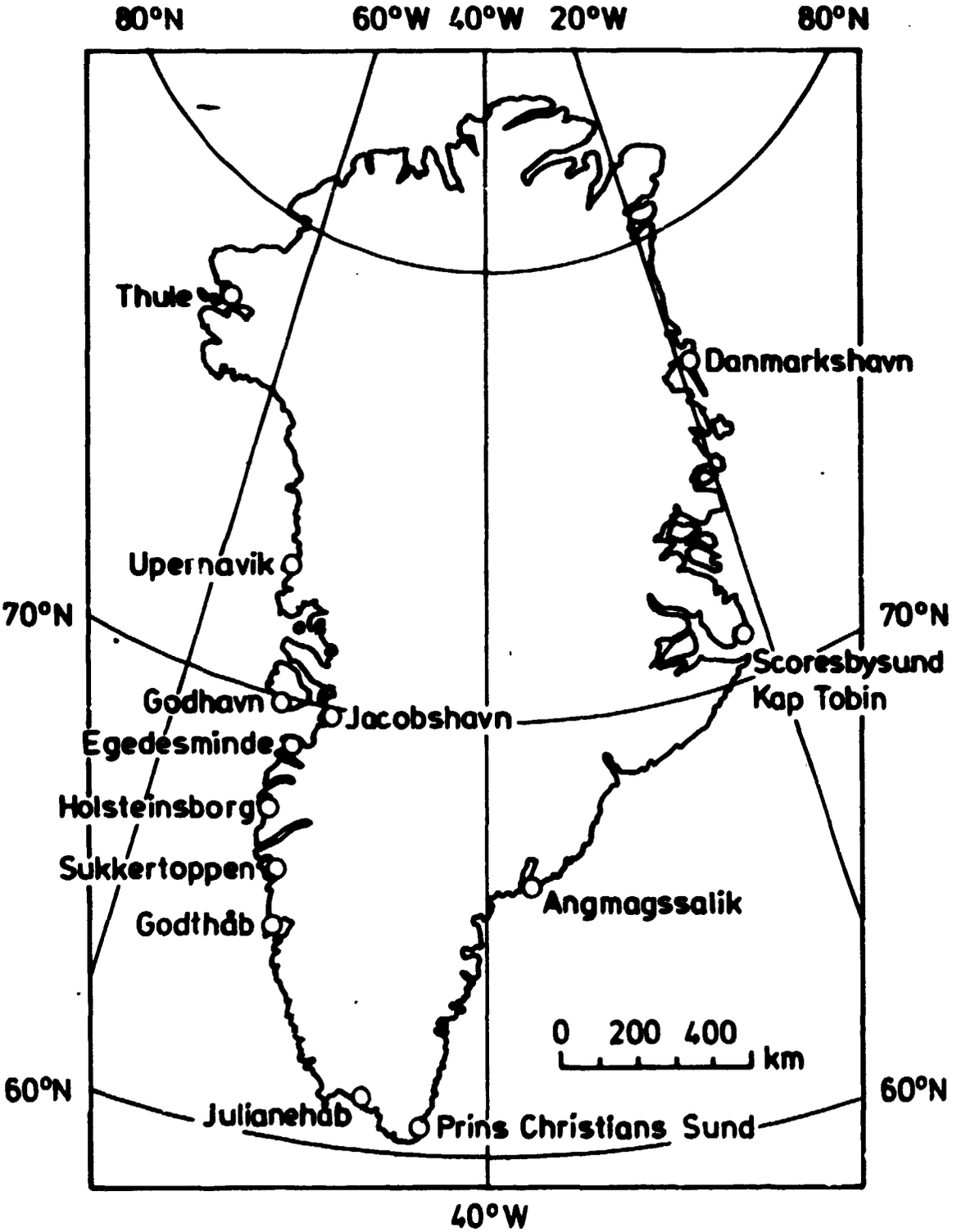

Fig. 1. Greenland.

1. INTRODUCTION

1.1.

In 1981 the sampling programme was similar to that used in previous years but for a few minor modifications.

1.2.

As hitherto, samples were collected through the local district physicians and the head of the telestations.

1.3.

The estimated mean diet in Greenland was the same as that in 1962, i.e., it agreed with the estimate given by Professor E. Hoff-Jørgensen, Ph.D.

1.4.

The environmental studies in Greenland were carried out together with corresponding investigations in Denmark (cf. Risø Report No. 469[2]) and in the Faroes (cf. Risø Report No. 470[3]).

1.5.

The present report does not repeat information concerning sample collection and analysis already given in ref. 1.

1.6.

Appendix A contains the Pu and Am analysis of a number of Fucus and Laminaria samples collected by GGU in 1969. In Appendix B we have as uncommented tables given further results of our investigations of transuranics (Pu and Am) and ^{137}Cs at Thule in August 1979. The expedition to Thule in 1979 was supported by the Commission of the European Communities with funds from its Radiation Protection programme.

2. RESULTS AND DISCUSSION

2.1. Strontium-90 in precipitation

Table 2.1.1 shows the results of the measurements.

Table 2.1.1. Strontium-90 in precipitation in Greenland in 1981. (Sampling area: 0.02 m^2)

Location (m precipitation)	Unit	Jan-March	April-June	July-Sept	Oct-Dec	1981
Upernavik	Bq m^{-3}	9.8	50	18.6	7.4	14.8
I 0.376	Bq m^{-2}	0.82	1.18	2.7	0.88	5.6
Godthåb	Bq m^{-3}	13.3	19.5	24	7.8	16.7
I 0.763	Bq m^{-2}	2.3	3.3	5.7	1.45	12.8
Prins Chr. Sund	Bq m^{-3}	lost	34			
	Bq m^{-2}		10.7			
Scoresbysund	Bq m^{-3}	5.7 *	30	14.9	11.2	13.9
I 0.396	Bq m^{-2}	1.05*	3.0	0.91	0.55	-5.5
Danmarkshavn	Bq m^{-3}	21	32		49 A	
	Bq m^{-2}	0.39	0.48		0.38 A	

*Combined with Oct-Dec 1980.

The ^{90}Sr fallout in 1981 at the Greenland stations were approximately two times the 1980 figures. In Denmark[2] and the Faroes[3] the fallout increased by a factor of 3 from 1980 to 1981.

Fig. 2.1 shows the accumulated ^{90}Sr at the various stations in Greenland, since measurements began in 1962.

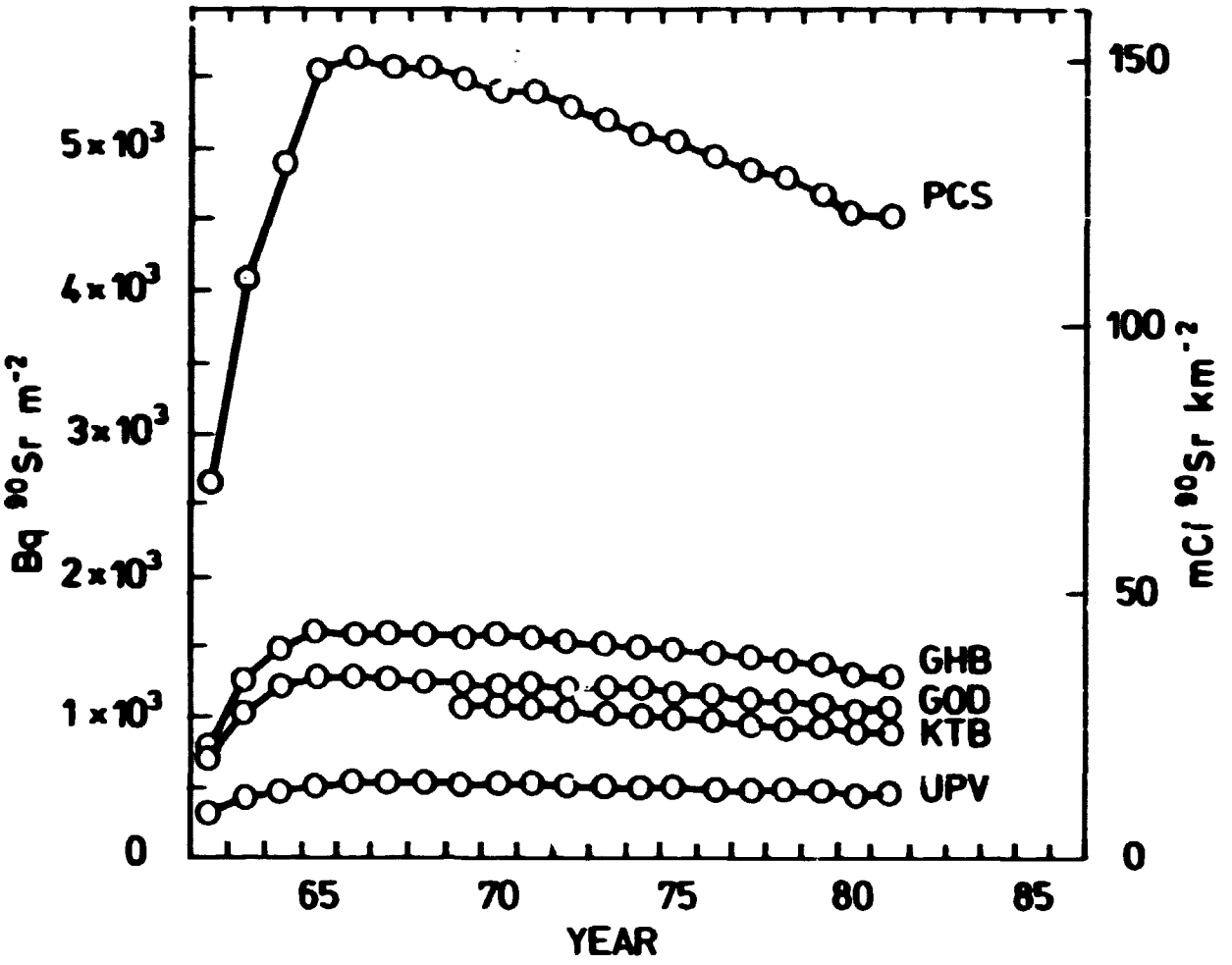

Fig. 2.1. Accumulated ^{90}Sr at Prins Chr. Sund, Godthåb, Godhavn, Kap Tobin and Upernavik calculated from precipitation measurements since 1962. The accumulated fallout by 1962 was estimated from the Danish data (cf. Risø Report No. 447[2], Appendix D) and from the ratio between the ^{90}Sr fallout at the Greenland stations and the fallout in Denmark in the period 1962-1974.

2.2. Strontium-90 in sea water

Due to a strike in Greenland in the summer of 1981 no samples of sea water was collected.

2.3. Strontium-90 and Cesium-137 in terrestrial animals

Five samples of lamb were received from SW-Greenland in 1981. The mean levels were 0.28 Bq ^{90}Sr kg^{-1} meat and 66 Bq ^{137}Cs kg^{-1}. The lamb bones contained 3200 Bq ^{90}Sr (kg Ca)$^{-1}$.

Three samples of reindeer from Egedesminde showed mean levels of 0.117 Bq ^{90}Sr kg^{-1} meat, 38 Bq ^{137}Cs kg^{-1} meat and in bone: 1790 Bq ^{90}Sr $(kg\ Ca)^{-1}$.

Table 2.3. Strontium-90 and Cesium-137 in terrestrial animals in Greenland in 1981

Date	Location	Sample type	Bq ^{90}Sr kg^{-1}	Bq ^{90}Sr $(kg\ Ca)^{-1}$	Bq ^{137}Cs kg^{-1}	Bq ^{137}Cs $(kg\ K)^{-1}$
March	Egedesminde	Reindeer meat I	0.055	610 (1910)	7.2	2100
"	- " -	" " II	0.194	1700 (1820)	6.1	1800
Sept	- " -	" "	0.101	1340 (1640)	102	28000
Aug	SW-Greenland (KGH)	Lamb meat I + V	0.33	4500 (3700)	19.7	9200
		" " II		(2800)	117	45000
		" " III	0.194	2300	12.6	5700
		" " IV			62	23000
		" " V			118	45000

Bone levels are shown in brackets.

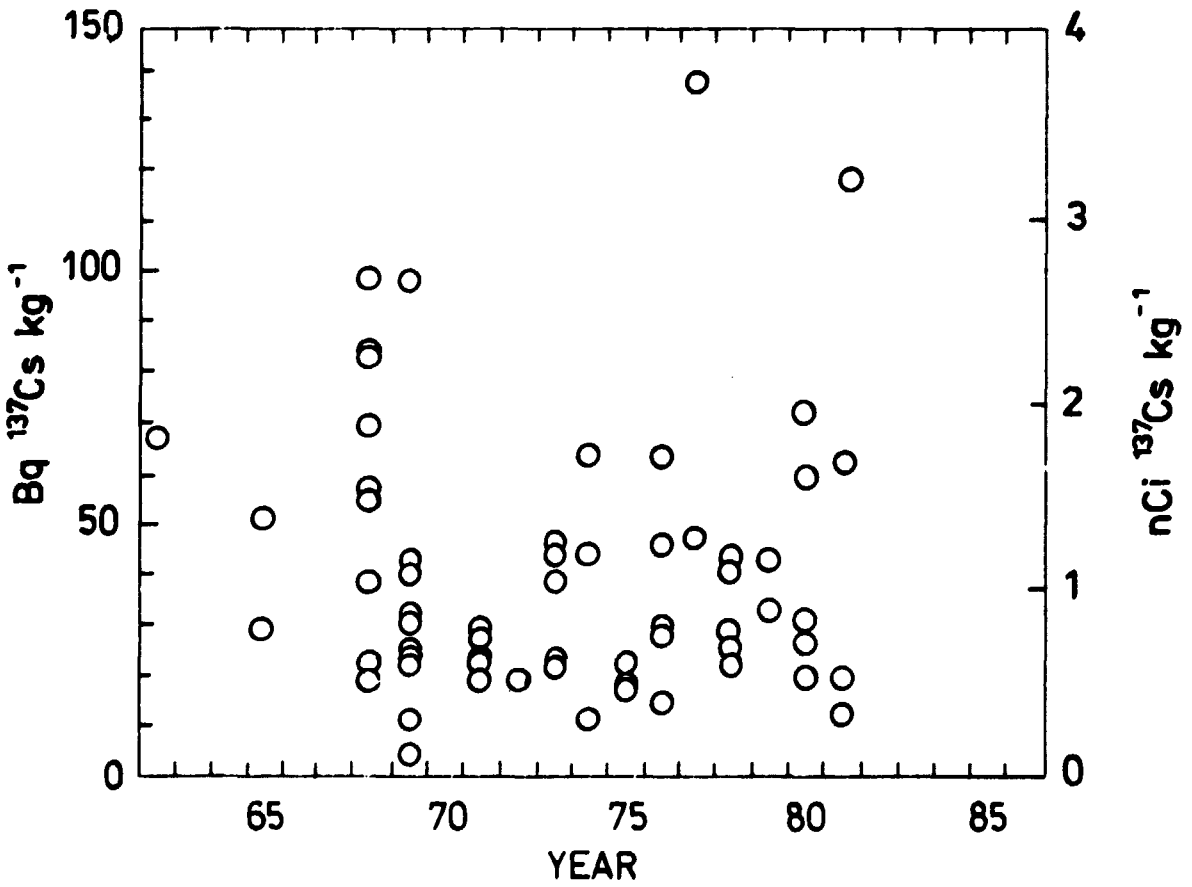

Fig. 2.3.1. Cesium-137 in mutton, 1962-1981.

2.4. Strontium-90 and Cesium-137 in sea animals

The mean levels in fish meat were: 0.003 Bq ^{90}Sr kg^{-1}, 0.46 Bq ^{137}Cs kg^{-1}, and seal contained 0.002 Bq ^{90}Sr kg^{-1} meat and 0.84 Bq ^{137}Cs kg^{-1}. The mean levels in shrimps were 0.018 Bq ^{90}Sr kg^{-1} flesh and 0.17 Bq ^{137}Cs kg^{-1}. Whale meat contained 0.001 Bq ^{90}Sr kg^{-1} and 1.02 Bq ^{137}Cs kg^{-1}.

Table 2.4.1. Strontium-90 and Cesium-137 in sea animals collected in Greenland in 1981

Date	Location	Sample	Bq ^{90}Sr kg^{-1}	Bq ^{90}Sr (kg Ca)$^{-1}$	Bq ^{137}Cs kg^{-1}	Bq ^{137}Cs (kg K)$^{-1}$
	Angmagssalik	Seal meat	0.002 B	19 B (2.4)	0.84	290
Sept	Egedesminde	Whale meat	0.001 B	33 B	1.02	330
	SW-Greenland (KGH)	Salmon flesh I	0.002 B	13 B (3 B)	0.33	105
	- " -	- " - II	0.004 A	17.5 A (12 B)	0.38	112
	- " -	Cod flesh I	0.002 B	20 B	0.51	139
	- " -	- " - II	0.004 B	59 B	0.60	151
	- " -	Shrimps flesh	0.027	49	0.10 A	65 A
	Jacobshavn	- " -	0.009 A	14 A	0.24	70

Bone levels are shown in brackets.

2.5. Strontium-90 and Cesium-137 in vegetation

No samples of terrestrial vegetation was obtained in 1981.

A fucus sample was obtained from Upernavik in August (Table 2.5.1). As compared with fucoids collected around Iceland in June 1981[3] the Fucus sample from Upernavik showed similar concentrations of most radionuclides. However, the $^{239,240}Pu$ concentration was six times higher in the Upernavik sample and of the same order of magnitude as a Fucus vesiculosus sample collected at Angmagssalik in September 1981 which contained 0.42 Bq $^{239,240}Pu$ kg^{-1} dry weight.

Table 2.5.1. Radionuclides in Fucus collected at Upernavik in August 1981

	Bq kg^{-1} dry weight	rel. S.D. due to counting
^{54}Mn	1.4	9%
^{90}Sr	0.62	7%
^{95}Zr	8.1	12%
^{95}Nb	20.6	4%
^{106}Ru	3	36%
^{125}Sb	2.5	7%
^{137}Cs	0.61	15%
^{144}Ce	15	4%
^{226}Ra	1.9	6%
$^{239,240}Pu$	0.325	10%

The dry matter content was 19%. The sample contained 31 g K kg^{-1} dry matter and 16 g Ca kg^{-1} dry matter.

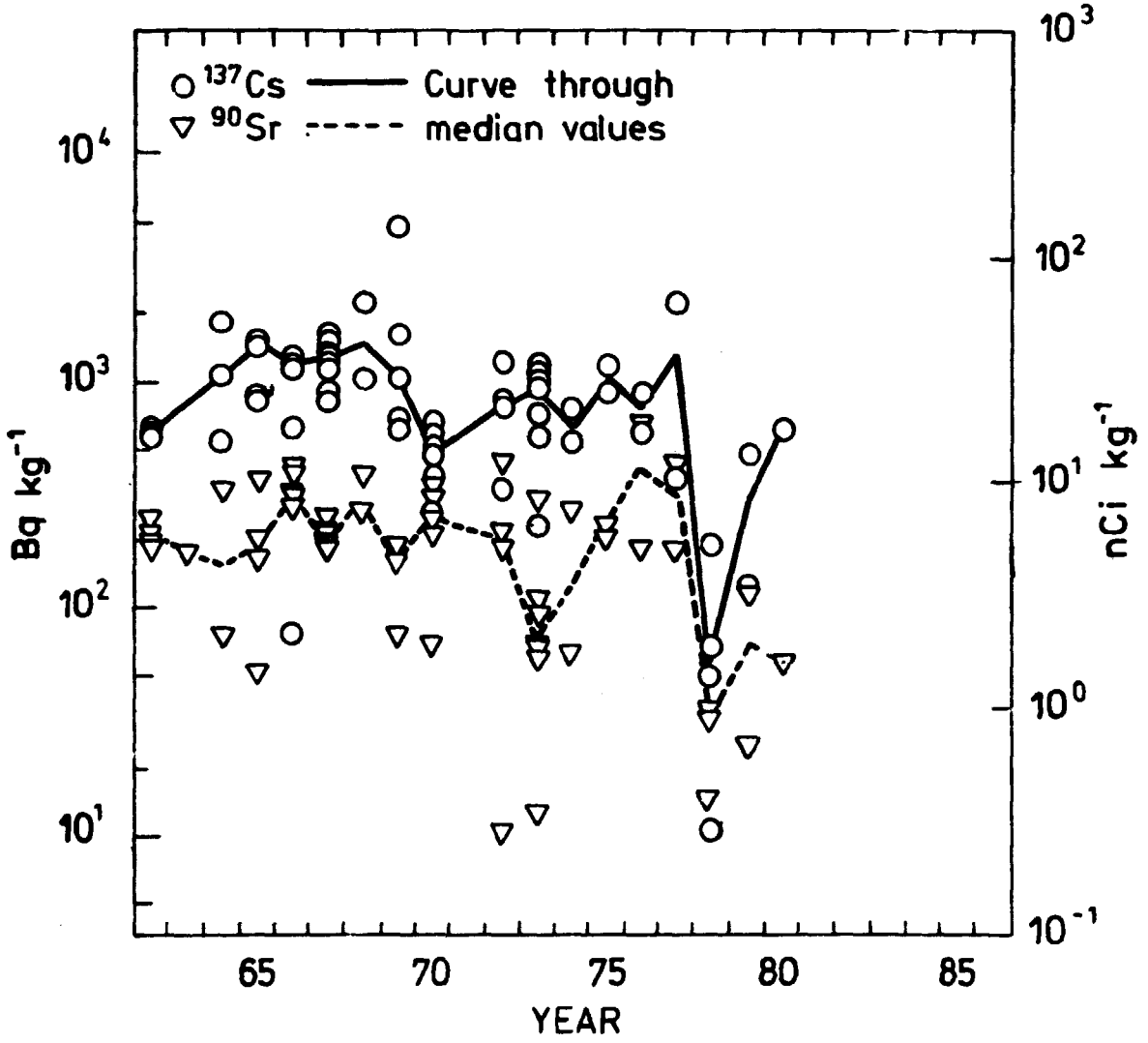

Fig. 2.5. Cesium-137 and Strontium-90 in lichen (fresh weight) collected along the Greenlandic coast, 1962-1981.

2.6. Strontium-90 in drinking water

Quarterly samples of drinking water were collected from a number of locations in Greenland. Due to a strike no samples were obtained from the last half of the year. Table 2.6.1 shows the results from 1981, and Fig. 2.6 the geometric annual means of all samples for the period 1962-1981.

As in previous years, we found it most expedient to choose the geometric mean of all figures, i.e. 41 Bq ^{90}Sr m^{-3} (1.1 pCi l^{-1}) as representative of the mean level of ^{90}Sr in Greenland drinking water in 1981, this level was higher than that observed in

Table 2.6.1. Strontium-90 in drinking water collected in Greenland in 1981. (Unit: Bq m^{-3})

Location	Jan-March	April-June	July-Sept	Oct-Dec
Danmarkshavn	52			
Prins Chr. Sund	320	112		
Upernavik	8.0	8.0		
Scoresbysund				20

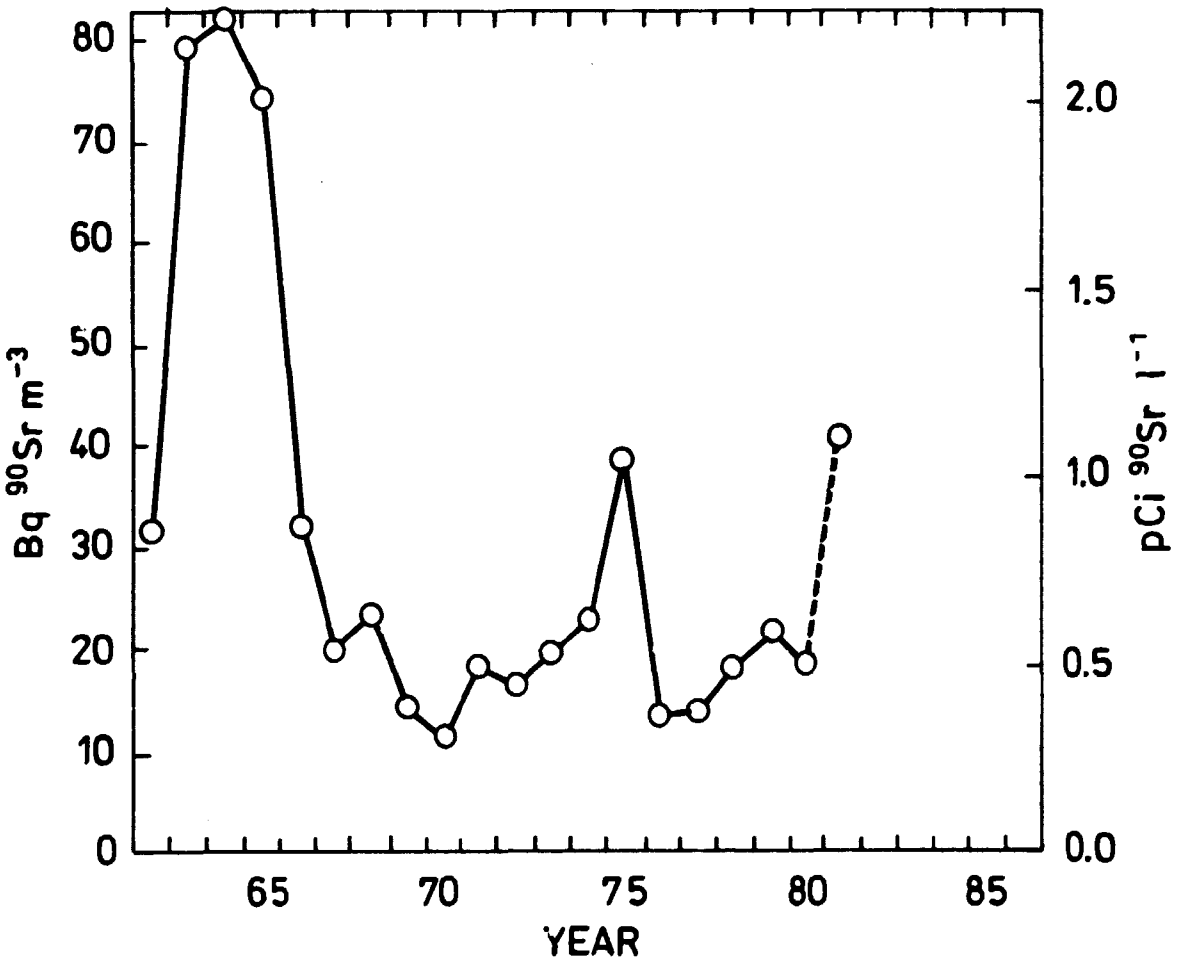

Fig. 2.6. Strontium-90 in Greenlandic drinking water (Geometric mean), 1962-1981.

recent years (Fig. 2.6) but this may be due to the few samples obtained. The levels from Prins Chr. Sund are still surprisingly high as compared to present rain concentrations (cf. Table 2.1.1). We have suggested that evaporation from the drinking

water reservoirs was responsible for the higher ^{90}Sr levels. Tritium measurements show (Table 2.6.2) that the drinking water at Prins Chr. Sund shows similar tritium levels as drinking water from other locations, hence evaporation seems to be a possible explanation. The high ^{90}Sr levels at PCS may, however, also be due to extraction of old deposited ^{90}Sr activity from the soil by the water collected for drinking. This would also be compatible with "normal" tritium concentrations.

At Upernavik we find a surprisingly high tritium/^{90}Sr ratio in the drinking water. This could mean that ^{90}Sr by contact with soil minerals is depleted from the water at Upernavik. Here we should thus have the opposite situation of that in Prins Chr. Sund, perhaps due to the permafrost at Upernavik.

Table 2.6.2. Tritium in drinking water collected in Greenland in 1981. (Unit: kBq m^{-3})

Location	Jan-March	April-June
Danmarkshavn	4.6±0.92	
Prins Chr. Sund	3.2±1.67	
Upernavik	7.8±0.37	7.0±1.11

The error term is 1 S.E. of the mean of double determinations.

3. ESTIMATE OF THE MEAN CONTENTS OF ^{90}Sr AND ^{137}Cs IN THE HUMAN DIET IN GREENLAND IN 1981

3.1. The annual quantities

The estimate of the daily per capita intake of the different foods in Greenland is still based on the figures given in 1962 by Professor E. Hoff-Jørgensen, Ph.D., in Risø Report No. 65[1].

3.2. Milk products

All milk consumed in Greenland was imported as milk powder from Denmark. The mean radioactivity content in milk prepared from Danish dried milk produced in 1981 was 0.130 Bq ^{90}Sr kg^{-1} and 0.134 Bq ^{137}Cs kg^{-1} [2].

Cheese was also imported from Denmark and contained 0.92 Bq ^{90}Sr kg^{-1} and 0.097 Bq ^{137}Cs kg^{-1}.

3.3. Grain products

All grain was imported from Denmark. It is assumed that only grain from the harvest of 1980 was consumed in Greenland during 1981. The daily per capita consumption was: rye flour (100% extraction): 80 g, wheat flour (75% extraction): 110 g, rye flour (70% extraction): 20 g, biscuits (rye, 100% extraction): 27 g, and grits: 25 g. The content of ^{90}Sr in these five products was 0.74, 0.17, 0.15, 0.55 and 0.31 Bq kg^{-1} respectively. Hence the mean content of ^{90}Sr in grain products was 0.40 Bq kg^{-1}. The content of ^{137}Cs in the five products was 0.33, 0.12, 0.16, 0.24 and 0.13 Bq kg^{-1}. Hence the mean content of ^{137}Cs in grain products was 0.20 Bq kg^{-1}.

The activity levels in rye flour (100% extraction), wheat flour (75% extraction), and grits were all taken from Tables 5.9.1 and 5.9.2 in Risø Report No. 447[2]. The ^{90}Sr level in rye flour (70% extraction) was calculated analogously with the level in wheat flour (75% extraction), i.e. as one-fifth of the whole-grain activity. The ^{137}Cs content in rye flour (70% extraction) was calculated as one half of the whole-grain level in rye in analogy with the ratio between ^{137}Cs in whole wheat grain and in wheat flour (75% extraction)[2]. The ^{90}Sr and ^{137}Cs contents in biscuits were calculated by dividing the levels of the rye flour (100% extraction) by 1.35, since 1 kg flour yields 1.35 kg bread[2].

3.4. Potatoes, other vegetables, and fruit

The Danish mean levels for 1981 were used[2] since the local production is insignificant compared with imports from Denmark.

The Danish mean levels were: in potatoes 0.076 Bq ^{90}Sr kg^{-1} and 0.11 Bq ^{137}Cs kg^{-1}, in other vegetables 0.38 Bq ^{90}Sr kg^{-1} and 0.086 Bq ^{137}Cs kg^{-1}, and in fruit 0.044 Bq ^{90}Sr kg^{-1} and 0.09 Bq ^{137}Cs kg^{-1}.

3.5. Meat

Nearly all meat consumed in Greenland is assumed to be of local origin. Approx. 10% comes from sheep, 5% from reindeer, 60% from seals, 5% from whales, and 20% from sea birds and eggs.

The activities in lamb and reindeer were estimated from 2.3. Seal and whale were estimated from 2.4. The levels of sea birds and eggs were taken from the 1978 analyses[1]. Hence the mean levels in Greenland meat from 1981 were 0.037 Bq ^{90}Sr kg^{-1} and 9.13 Bq ^{137}Cs kg^{-1}.

(^{90}Sr: $0.1 \times 0.28 + 0.05 \times 0.12 + 0.6 \times 0.002 + 0.05 \times 0.001 + 0.2 \times 0.007 = 0.037$ Bq kg^{-1})

(^{137}Cs: $0.1 \times 66 + 0.05 \times 38 + 0.6 \times 0.84 + 0.05 \times 1.02 + 0.2 \times 0.35 = 9.13$ Bq kg^{-1})

3.6. Fish

All fish consumed was of local origin, and the mean levels from 2.4 were used, i.e. 0.003 Bq ^{90}Sr kg^{-1} and 0.46 Bq ^{137}Cs kg^{-1}.

3.7. Coffee and tea

The Danish figures for 1981[2] were used for coffee and tea, i.e. 0.66 Bq ^{90}Sr kg^{-1} and 2.21 Bq ^{137}Cs kg^{-1}.

3.8. Drinking water

The geometric mean calculated in 2.6 was used as the mean level of ^{90}Sr in drinking water, i.e. 41 Bq ^{90}Sr m^{-3}. The ^{137}Cs content was as previously[1] estimated at 1/4 of the ^{90}Sr content, i.e approx. 10 Bq ^{137}Cs m^{-3}.

Tables 3.1 and 3.2 show the diet estimates of ^{90}Sr and ^{137}Cs respectively.

Table 3.1. Estimate of the mean content of ^{90}Sr in the human diet in Greenland in 1981

Type of food	Annual quantity in kg	Bq ^{90}Sr per kg	Total Bq ^{90}Sr	Percentage of total Bq ^{90}Sr in food
Milk and cream	78	0.130	10.14	11.9
Cheese	2.5	0.92	2.30	2.7
Grain products	95.6	0.40	38.24	44.9
Potatoes	32.8	0.076	2.49	2.9
Vegetables	5.5	0.38	2.09	2.4
Fruit	13.5	0.044	0.59	0.7
Meat and eggs	45.6	0.037	1.69	2.0
Fish	127.6	0.003	0.38	0.4
Coffee and tea	7.3	0.66	4.82	5.7
Drinking water	548	0.041	22.47	26.4
Total			85.21	

The mean annual calcium intake is estimated to be 0.56 kg (approx. 0.2-0.25 kg creta praeparata). Hence the $^{90}Sr/Ca$ ratio in Greenland total diet in 1981 was 152 Bq ^{90}Sr (kg Ca)$^{-1}$ or 4.1 pCi ^{90}Sr (g Ca)$^{-1}$ and the daily intake was 0.23 Bq ^{90}Sr or 6.3 pCi ^{90}Sr.

Table 3.2. Estimate of the mean content of ^{137}Cs in the human diet in Greenland in 1981

Type of food	Annual quantity in kg	Bq ^{137}Cs per kg	Total Bq ^{137}Cs	Percentage of total Bq ^{137}Cs in food
Milk and cream	78	0.134	10.45	2.0
Cheese	2.5	0.097	0.24	0.1
Grain products	95.6	0.20	19.12	3.6
Potatoes	32.8	0.11	3.61	0.7
Vegetables	5.5	0.086	0.47	0.1
Fruit	13.5	0.09	1.22	0.2
Meat and eggs	45.6	9.13	416.33	78.3
Fish	127.6	0.46	58.70	11.0
Coffee and tea	7.3	2.21	16.13	3.0
Drinking water	548	0.010	5.48	1.0
Total			531.75	

The mean annual potassium intake is estimated to be approx. 1.2 kg. Hence the $^{137}Cs/K$ ratio becomes 443 Bq ^{137}Cs $(kg\ K)^{-1}$ or 12.0 pCi ^{137}Cs $(g\ K)^{-1}$. The daily intake in 1981 from food was 1.46 Bq ^{137}Cs or 39 pCi ^{137}Cs.

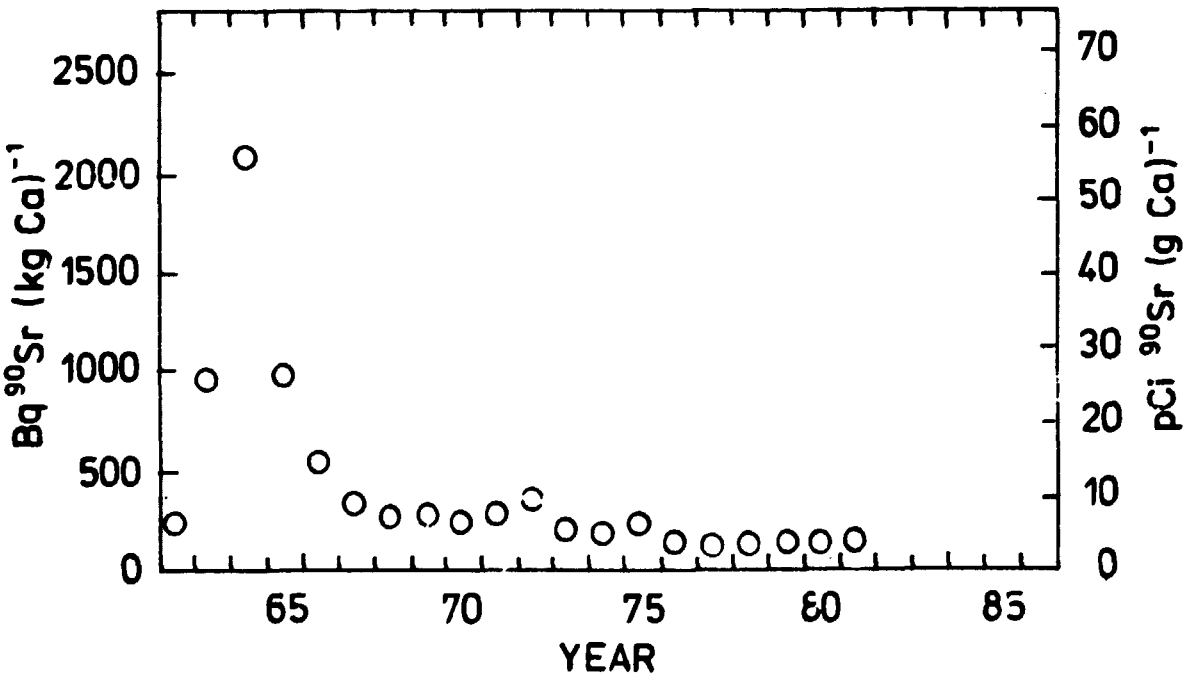

Fig. 3.1. Strontium-90 in Greenlandic diet, 1962-1981.

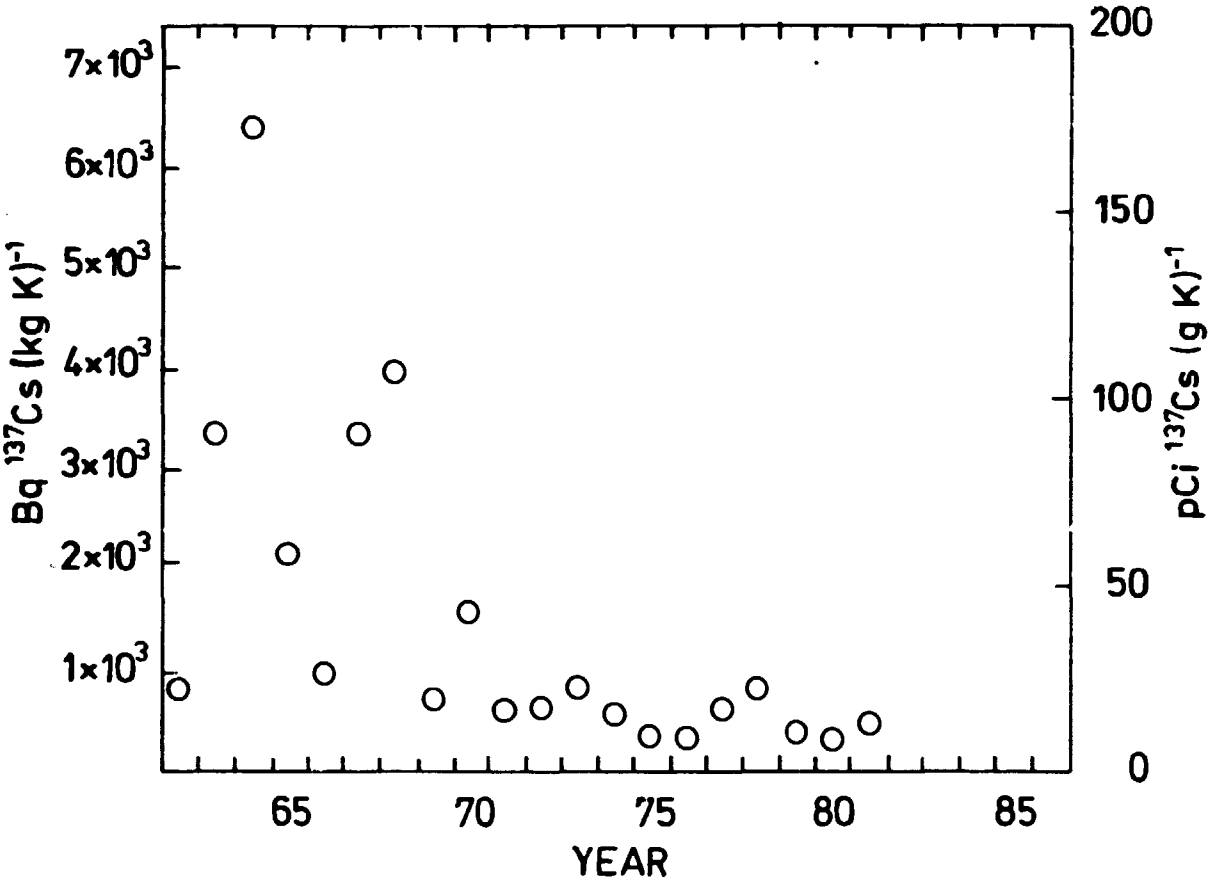

Fig. 3.2. Cesium-137 in Greenlandic diet, 1962-1981.

3.9. Discussion

The most important ^{90}Sr source in the Greenland diet is still grain products, which contribute 45% of the total ^{90}Sr content in the diet. Approx. 70% of the ^{90}Sr in the food consumed in Greenland in 1981 originated from imported Danish food.

Meat is still the most important ^{137}Cs source in the Greenland diet, contributing 78% of the total content in 1981. Approx. 90% of the ^{137}Cs in the Greenland diet in 1981 came from local products.

As compared with the 1980 figures, the ^{90}Sr contents in the total diet in 1981 was 18% higher than the 1980 level.

The ^{137}Cs level was 48% higher than the level found in 1980. As earlier discussed[1] the great variations from year to year are

primarily due to the variations in the ^{137}Cs levels in the meat samples obtained.

To estimate the maximum per capita intakes of ^{90}Sr and ^{137}Cs in Greenland in 1981 we assume[1] that the only grain product consumed by a person is dark rye bread, and that he only eats lamb meat. His daily intake of ^{90}Sr is thus 0.35 Bq and his ^{137}Cs intake 8.6 Bq day^{-1} (using the quantities in Tables 3.1 and 3.2). At the lower limit we can imagine a person eating white bread and seal and drinking water with hardly any activity (e.g. water formed by the melting of old ice). In this case the daily intakes are 0.07 Bq ^{90}Sr and 0.39 Bq ^{137}Cs. Hence the ratios between the levels in the maximum and minimum diets become 5 for ^{90}Sr and 22 for ^{137}Cs.

The ^{90}Sr content of the Greenland diet in 1981 was 91% of the estimated Danish mean content[2], and 71% of the Faroese level[3]. The ^{137}Cs level in the total diet in Greenland was 3.3 times that of the Danish diet and 21% of the Faroese diet level.

4. CONCLUSION

4.1.

The ^{90}Sr fallout rates in 1981 were the following: Godthåb: 12.8 Bq ^{90}Sr m^{-2}; Scoresby Sund: approx. 5 Bq m^{-2}; Upernavik: 5.6 Bq ^{90}Sr m^{-2}. The accumulated fallout levels by the end of 1981 were estimated at approx. 1030 Bq ^{90}Sr m^{-2} at Godhavn, 1280 Bq ^{90}Sr m^{-2} at Godthåb, 4520 Bq ^{90}Sr m^{-2} at Prins Chr. Sund, and 455 Bq ^{90}Sr m^{-2} at Upernavik.

4.2.

The food consumed in Greenland in 1981 contained on the average 152 Bq ^{90}Sr $(kg\ Ca)^{-1}$, and the daily mean intake of ^{137}Cs was estimated at 1.46 Bq. The most important ^{90}Sr contributor to the diet were grain products accounting for approx. 45% of the total ^{90}Sr content of the diet. Cesium-137 originated mainly from meat (reindeer and lamb) and fish, contributing approx. 90% of the total ^{137}Cs content of the diet.

4.3.

No ^{90}Sr analyses of human bone samples have hitherto been carried out on the population of Greenland. Considering the estimated ^{90}Sr levels in the diet, it seems probable[4], however, that the 1981 ^{90}Sr levels of humans in Greenland were on the average rather similar to those found in Denmark, i.e. the mean levels in human bone in Greenland were approx. 30 Bq ^{90}Sr $(kg\ Ca)^{-1}$ (vertebrae). From diet measurements the ^{137}Cs content in Greenlanders was estimated at 1300 Bq ^{137}Cs $(kg\ K)^{-1}$.

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APPENDIX A

Brown algae and Mytilus collected in Greenland 1969, 1970 and 1979

In 1969 and 1970 The Geological Survey of Greenland (GGU) collected a number of algae samples in the Scoresby Sund district of East Greenland (cf. Figs. 1 and A.1) and in the Julianehåb district in Southwest Greenland at Narssaq. The purpose of the sampling was to examine whether or not algae could be used as indicators of uranium deposits. Some of these samples have recently been analysed for Pu, Am, and γ-emitting radionuclides (cf. Tables A.1 and A.2).

It appears that the mean Pu level in 5 Fucus samples collected in the Scoresby Sund district was 4.9 Bq ^{239,240}Pu kg^{-1} (1 S.D.: 2.5 Bq kg^{-1}). This may be compared with the concentration found

Table A.1. Transuranics in brown algae collected in Greenland in 1969-1970

Location	Species		Date	^{239,240}Pu Bq kg^{-1} dry weight	$\frac{^{238}Pu}{^{239,240}Pu}$	$\frac{^{241}Am}{^{239,240}Pu}$	No.
Cap Brewster, North 70°06'N 22°03'W	Laminaria	stems	Aug 7, 1969	0.92		0.29	284
East of Tow Glacier 69°56'N 22°30'W	- " -	stems leaves	Aug 1969	0.91		0.30	285
Turner Island, South 69°35'N 23°21'W	- " -	- " -	Aug 16, 1969	0.93	0.046	0.11	291
Jameson Land, Scoresbysund 70°37'N 24°09'W	- " -	- " -	Aug 18, 1969	0.31	0.037		305
Manby Peninsula 69°44'N 23°05'W	Fucus		Aug 21, 1969	3.89	0.040	0.27	287
Turner Island, North-East 69°38'N 23°15'W	- " -		Aug 16, 1969	4.21	0.051		289
Bjerneeer, Scoresbysund 71°00'N 25°23'W	- " -		July 18, 1969	8.40	0.12	0.36	293
Hurry Fjord, Scoresbysund 70°35'N 22°25'W	- " -		Aug 23, 1969	6.18	0.047	0.22	307
Flyver Fjord, Scoresbysund 71°33'N 27°48'W	- " -		Aug 24, 1969	1.79	0.105	0.28	317
Kangerdluarsuk (Narssaq) 60°50'N 46°00'W	- " -		1970	0.86	0.094	0.22	324
Ilua (Narssaq) 60°59'N 45°50'W	- " -		1970	1.06	0.097		323

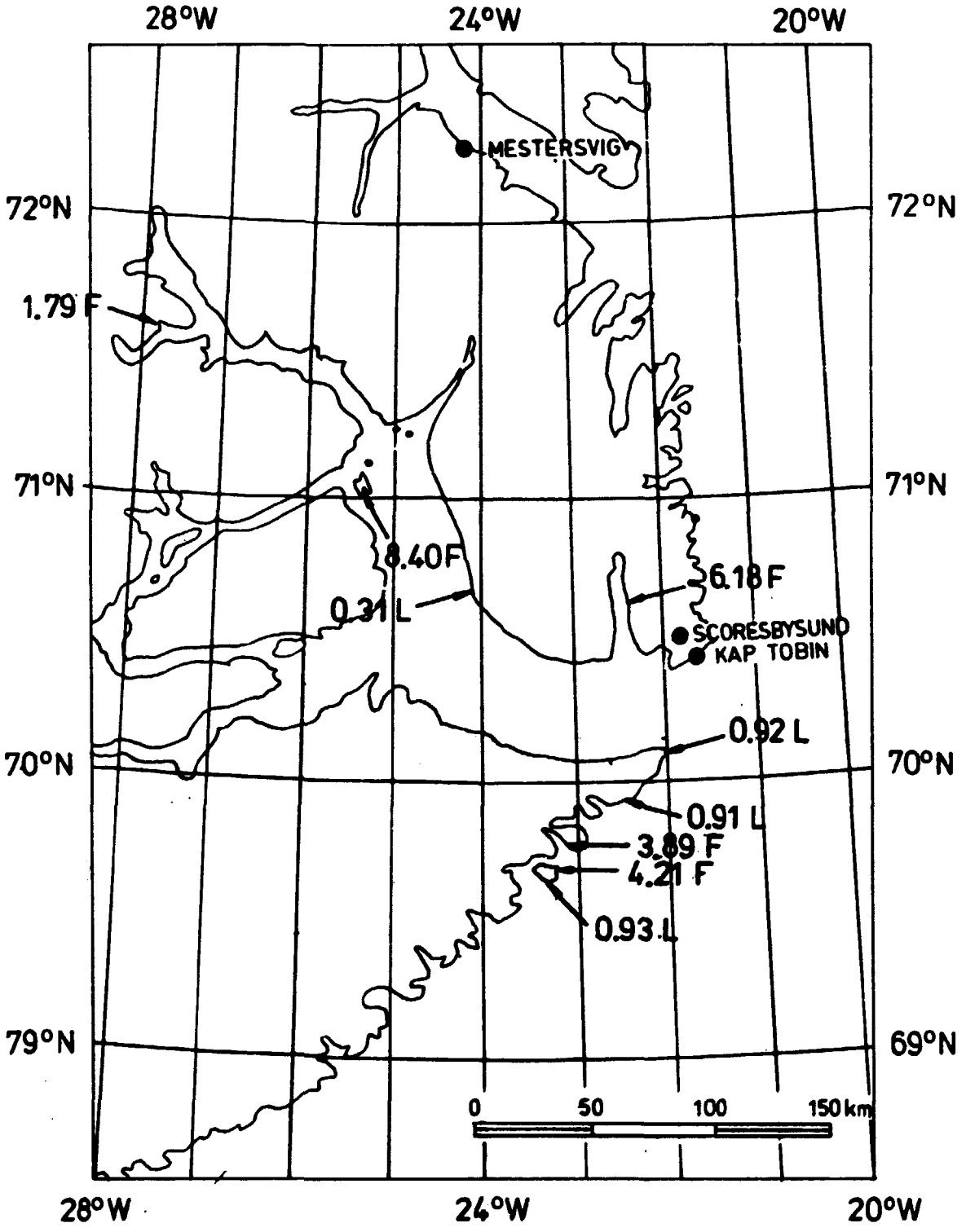

Fig. A.1. Plutonium-239,240 in Laminaria (L) and Fucus (F) collected in East Greenland in July-August 1969. (Unit: Bq kg^{-1} dry weight).

Table A.2. Gamme-emitting nuclides in brown algae collected in Greenland in 1969-1970

No. cf. Table A.1	Species	Year	Bq kg^{-1} dry weight ^{60}Co	^{137}Cs	^{226}Ra	kg K kg^{-1} dry weight
289	Fucus	1969	3.9 (18)	35.6 (1.3)	6.2 (5)	0.0018 (5)
285	Laminaria	1969	-	5.1 (6.3)	3.9 (8)	0.030 (1)
293	Fucus	1969	-	5.6 (14)	12.0 (7)	0.0028 (9)
324	Fucus	1970	-	3.1 (14)	9.1 (5)	0.023 (1)

In brackets: rel. S.D. in % due to counting.

in a Fucus sample collected at Danmarkshavn (cf. Fig. 1) in 1968[5], which contained 6.7 Bq ^{239,240}Pu kg^{-1} dry weight. In other parts of Greenland[5] the Pu levels seemed to have been lower than those found on the east coast. At Prins Chr. Sund in 1968 we thus found 2.0, at Godthåb 1.9, and at Thule (outside the accident area) 2.8 Bq kg^{-1}. The two Fucus samples in Table A.1 from SW Greenland, Narssaq, collected in 1970 contained approximately 1 Bq ^{239,240}Pu kg^{-1} dry weight. In 1979 the Fishery Investigations of Greenland (GFU) collected a number of brown algae at Narssaq as well. These samples have been analysed earlier for ^{90}Sr and ^{137}Cs (cf. Risø Report No. 423[1]). Table A.3 shows the results of the ^{239,240}Pu determinations. Compared with those from 1970 we notice a decrease from 1 Bq kg^{-1} to approximately 0.4 Bq kg^{-1} in Fucus. Furthermore, from Table A.3 it appears that the activity ratio of Fucus to Mytilus was 5.0 for Pu on a dry weight basis. This may be compared with the corresponding ratio found at Iceland and the Faroe Islands in 1981, which was 2.5[3].

Table A.2 shows γ-emitting nuclides in 3 samples of brown algae from the Scoresby Sund district and one from the Narssaq district. The samples from East Greenland showed the highest ^{137}Cs concentrations. One of them (No. 289) showed especially high concentrations. This sample also contained ^{60}Co.

From a sampling in 1981 around Iceland[3] we determined the concentration ratio of ^{137}Cs in fucoids to sea water as 260. If this ratio is applied in the samples in Table A.2, we would expect the surface sea water concentration in the Scoresby Sund district in 1969 to vary between 22 and 137 Bq ^{137}Cs m^{-3} and at Narssaq in 1970 to be 12 Bq m^{-3}. We have no ^{137}Cs sea water measurements from 1969 and 1970 but the ^{90}Sr concentrations in sea water collected at Danmarkshavn and Angmagssalik varied in 1969-1970 between 8 and 14 Bq ^{90}Sr m^{-3}. Sea water collected at Prins Christians Sund and Godthåb (the two locations closest to Narssaq) varied between 7 and 8 Bq ^{90}Sr m^{-3}. If the $^{137}Cs/^{90}Sr$ ratio in the waters around Greenland was 1.5 (as we have found in recent years[1]), we may estimate the expected ^{137}Cs concentrations in sea water at Scoresby Sund to be 12-21 Bq m^{-3} and at Narssaq to be 10-12 Bq m^{-3}. Hence we may conclude that the sample from Narssaq and the low sample from Scoresby Sund (No. 293) are in agreement with the expected water concentrations for 1969-1970. However, the high level in sample No. 289 exceeds the expected ^{137}Cs water levels by a factor of 5-10. The sample also contained ^{60}Co. The concentration corresponded to 11% of the ^{137}Cs concentration. Earlier we have seen samples at such a high level from East Greenland waters. A sample of Laminaria collected at 80°25'N and 16°03'W at the Swedish Ymer expedition in 1980 (Risø-R-449, Table D.2[1]) thus contained 47 Bq ^{137}Cs kg^{-1} dry weight. This sample also contained ^{60}Co corresponding to 2% of the ^{137}Cs activity. If we correct for decay from 1969 to 1980, the Scoresby Sund sample would have shown a $^{60}Co/^{137}Cs$ ratio of 0.92/27.6 = 0.03, i.e close to the ratio in the YMER-sample. The source of these enhanced levels of radionuclides ir East Greenland has not been identified. However, direct transport of activity, either by air, water, or ice, from the test site at Novaya Zemlya is a possible explanation.

Table A.3. Plutonium-239,240 in brown algae and Mytilus collected in June 1979 at Narssaq, SW-Greenland (~ 61°N, ~ 46°W)

Location Number	Sample	$^{239,240}Pu$ Bq kg^{-1} dry weight
T1	Ascophyllum nodosum	0.17 ±0.00
"	Mytilus edulis 4-8 cm	0.089
T5	Fucus vesiculosus	0.42 ±0.02
"	Mytilus edulis 2.5-5.5 cm	0.080
"	- " - 5-6 cm	0.079
"	- " - 6-8.5 cm	0.095
T7	Fucus vesiculosus	0.33 ±0.02

The error term is 1 S.E. of the mean of double determinations.

APPENDIX B

Biological samples from Thule

Tables B.1-B.18 show the provisional results of the plutonium and americium analysis on benthic animals collected at Thule in August 1979. Table B.19 presents the data on sea plants and Table B.20-B.24 show analysis of fish, sea birds, marine mammals and terrestrial samples respectively.

Table B.1. Plutonium and Americium in benthos collected at Thule, August 1979, at location: Carey Islands 76°43'N 73°00'W, 98 km from point of impact

Samp'e	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	1.9	0.070			17
Macoma shell	6.8	0.25		-	95
Brittlestars	~0	~0			53

Table B.2. Plutonium and Americium in benthos collected at Thule, August 1979, at location: B 76°40'N 70°uu'%, 24 km from pcint of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	2.1	0.078			18
Macoma shell	22 21	0.81 0.78	-		85
Hiatella shell	< 2	< 0.07			
Chlinocardium flesh	1.66 2.0	0.062 0.074			19 19
Chlinocardium shell	3.5 7.7	0.13 0.28		0.62	80 90
Brittlestars	< 3 5.7	< 0.1 0.21			
Seaurchin	5.0	0.19	0.051	0.13	
Worms flesh	14 1.8	0.52 0.065			24 3.3
Worms shell	47 85	1.74 3.15	0.026	0.19	59 68

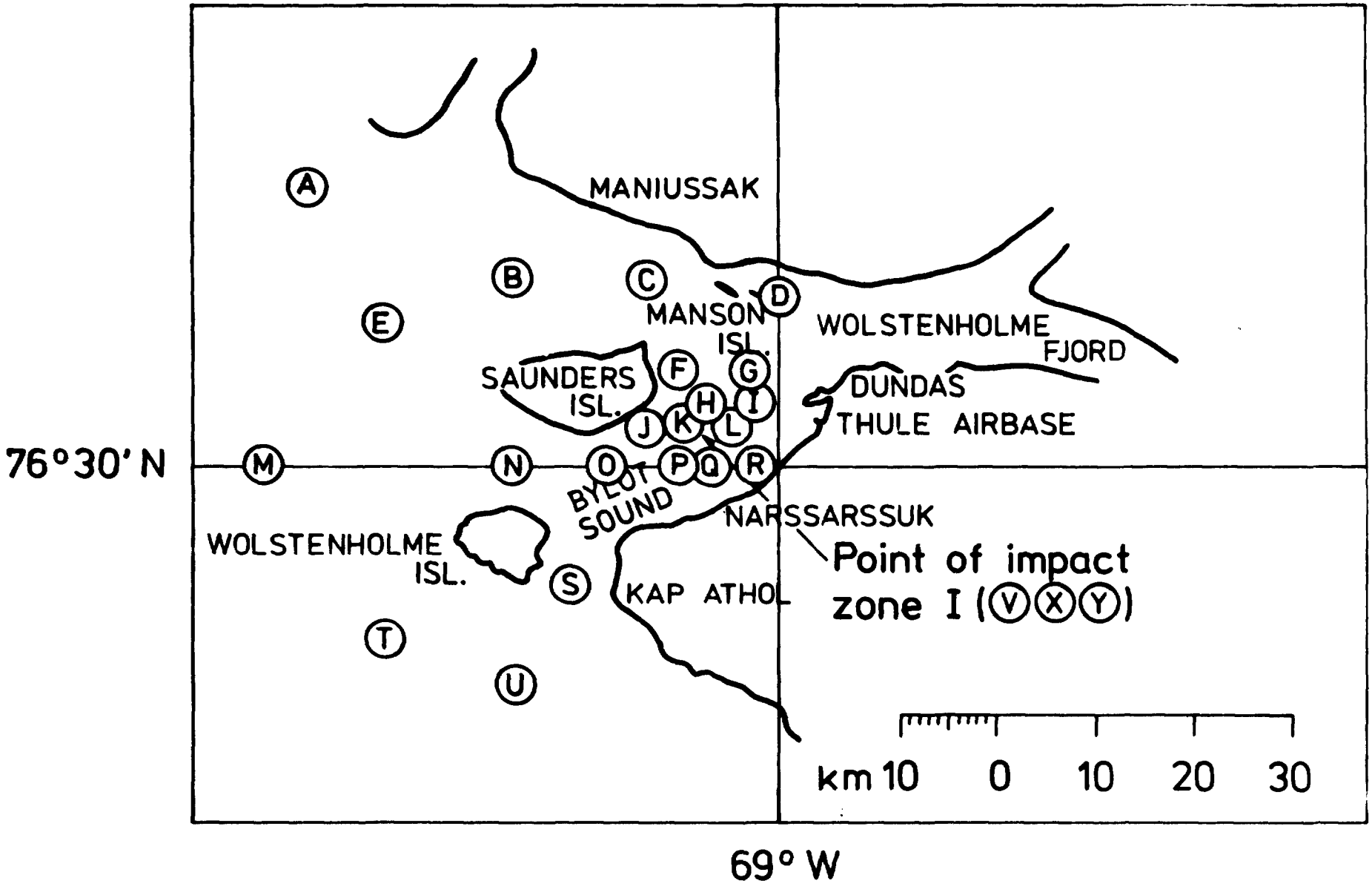

Fig. B.1. The sample locations at Thule.

Table B.3. Plutonium and Americium in benthos collected at Thule, August 1979, at location: C 76°40'N 69°30'W, 17 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma shell	69	2.56	0.019	0.19	
Macoma flesh	11	0.41			24
Brittlestars	61	2.26			
Worms flesh	66	2.44			
Worms shell	119	4.42		0.14	36 60

Table B.4. Plutonium and Americium in benthos collected at Thule, August 1979, at location: D 76°39'N 69°00'W, 16 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	7.2	0.27	0.036		15
Macoma shell	16.3	0.60		0.27	
Worms shell	37	1.36			62
Worms flesh	7.2	0.27			25
Brittlestars					69
Leda shell	12.7	0.47			81

Table B.5. Plutonium and Americium in benthos collected at Thule, August 1979, at location: E 76°37'N 70°30'W, 33 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	1.9	0.070			21
Macoma shell	5.6	0.21		0.30	82
Chlinocardium shell	58	2.17			87
Brittlestars	4.1	0.15			
Sea anemone	0.84				
Musculus niger shell	17.9	0.66			87
Worms flesh	7.0	0.26			39
Worms shell	72	2.7		0.27	56 71

Table B.6. Plutonium and Americium in benthos collected at Thule, August 1979, at location: P 76°35'N 69°25'W, 7 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	16.7	0.62	0.014		18
Macoma shell	68	2.52	0.029		79
Chlamys flesh	5.6	0.21	0.016		20
	1.6	0.06			58
Chlamys shell	29	1.07	0.029		97
	86	3.19	0.010		93
Hiatella flesh	80	2.96	0.014		18
	2.5	0.09			22
Hiatella shell	6.0	0.22			91
	8.1	0.30			85
Musculus flesh	3.8	0.14			20
Musculus shell	3.1	0.11			69
	10.3	0.38			67
Chlamocardium flesh	3.6	0.13	0.016		19
Chlamocardium shell	22	0.81			90
Astarte montagui flesh	3.7	0.14			10
Astarte shell	69	1.81	0.016		93 borealis
	73	2.70	0.026		(86)95 montagui
	20	0.74			
Astarte borealis flesh	3.3	0.12			21
Serripes flesh	3.1	0.11			21
Serripes shell	14	0.52			90
Sea urchin	11.2	0.41			33
	24	0.88			33
Balanus flesh	3.2	0.12			17
	1.6	0.06			17
Balanus shell	16.7	0.62			75
	9.4	0.35			83
Coral	19.4	0.72			71
Bryozoa	18	0.67	0.021		19
Spongia	7.4	0.27	0.020	0.13	11
	10.5	0.39	0.015		14
Worms flesh	15	0.56	0.024		27
Worms shell	68	2.52	0.016	0.20	53
	68	2.50			56
Snail flesh	2.8	0.102			25
Snail shell	8.2	0.30			56
Crinoidea	5.3	0.20			39
Brittlestars	8.3	0.31			63
Shrimps	7.2	0.27		0.22	25

Table B.7. Plutonium and Americium in benthos collected at Thule, August 1979, at location: G 76°35'N 69°05'W, 9 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma shell	39	1.07			60
Worms shell	750	28		0.084	61
Musculus niger shell	41	1.50			91
Shrimps	4.8	0.18			20

Table B.8. Plutonium and Americium in benthos collected at Thule, August 1979, at location: H 76°33'N 69°17'W, 3 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	153	5.7	0.015		20
Macoma shell	315	11.7	0.019	0.15	
Hiatella striata flesh	109	4.0		0.22	14
Hiatella striata shell	229	8.5			53
Clinocardium flesh	13.4	0.50		0.05	13
Clinocardium shell	204	7.5		0.14	63
Leda shell	137	5.1			65
Worms shell	514	19		0.13	65
Worms flesh	2600	97			26
Brittlestars	26	0.96			36

Table B.9. Plutonium and Americium in benthos collected at Thule, August 1979, at location: I 76°33'N 69°07'W, 5.5 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	23	0.85	0.026		17
Macoma shell	24	0.89		0.26	
Brittlestars	11.7	0.43			
Worms flesh	670	25	0.014		26
Worms shell	121	4.5		0.10	65
Leda shell					90

Table B.10. Plutonium and Americium in benthos collected at Thule, August 1979, at location: K 76°32'N 69°20'W, 1.7 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	6.2	0.23	0.013		
Macoma shell	329	12.2	0.022	0.18	
Brittlestars	57	2.11			
Clinocardium flesh	23	0.86		0.53	14
Clinocardium shell	114	4.2	0.013	0.16	68
Worms flesh	257	9.5		0.08	23
Worms shell	1470	54		0.10	59

Table B.11. Plutonium and Americium in benthos collected at Thule, August 1979, at location: L 76°32'N 69°10'W, 4 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma shell	140	5.2	0.014	0.17	82
Clinocardium shell	39	1.44			65
Hiatella striata flesh	48	1.79		0.13	17
Hiatella striata shell	38	1.40			56

Table B.12. Plutonium and Americium in benthos collected at Thule, August 1979, at location: N 76°30'N 70°00'W, 19 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Brittlestars	< 10	< 0.4			
Sea urchin	5.9	0.22			
Bryozoa	9.9	0.37	0.032		25
Sea scorpion	27	1.00			
Astarte borealis shell	5.1	0.19			93
Astarte montagui flesh	21	0.77			20
Astarte montagui shell	5.3	0.20			91
Snail	B.D.L.	B.D.L.			

Table B.13. Plutonium and Americium in benthos collected at Thule, August 1979, at location: O 76°30'N 69°40'W, 10 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1}	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	17.7	0.66	0.020		18
Macoma shell	58	2.15	0.024		82
Brittlestars	3.7	0.14			45
Hiatella flesh	21	0.78	0.019		17
Hiatella shell	66	2.44	0.023		89
Musculus shell					78
Musculus niger flesh	33	1.21			18
Chlinocardium flesh	8.4	0.31	0.018		17
Chlinocardium shell	21	0.78	0.024		88
Astarte montagui flesh	4.6	0.17			16
Astarte shell	14 37	0.52 1.37			90 borealis 88 montagui
Serripes flesh	6.5	0.24			18
Serripes shell	16	0.59			90
Sea urchin	12.7	0.47	0.014		30
Chrinoidea	1.74	0.064		0.52	39
Coral	13.3	0.49	0.018		21
Worms flesh	720	27	0.017		36
Worms shell	160	5.9		0.18	70
Brachiopod shell	9.4	0.35			85
Leda shell	12.4	0.46			82
Leda flesh	16.8	0.62			25
Soloaster	1.36	0.050			27
Snail flesh	4.3	0.16			8.3
Snail shell	7.2	0.27			54

Table B.14. Plutonium and Americium in benthos collected at Thule, August 1979, at location: P 76°30'N 69°25'W, 4 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1}	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	29	1.07	0.024		13
Macoma shell	169	6.3	0.082	0.10	
Chlinocardium flesh	12	0.44	0.021		12
Chlinocardium shell	68	2.52		0.30	
Musculus niger shell	8.7	0.32			60
Worms shell	2330	86		0.10	55
Worms flesh	145	5.4	0.035	0.15	24

Table B.15. Plutonium and Americium in benthos collected at Thule, August 1979, at location: Q 76°38'N 69°15'W, 3 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Brittlestars	24	0.89			
Macoma calcarea flesh	19	0.72		0.37	22
Macoma calcarea shell	130	4.81		0.21	89
Clamys flesh	1.55	0.058			24
Hiatella striata shell	37	1.36			79
Worms flesh	214	7.9		0.14	59
Worms shell	1100	41	0.012	0.10	67

Table B.16. Plutonium and Americium in benthos collected at Thule, August 1979, at location: R 76°30'N 69°10'W, 4 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma shell	25	0.93			76
Brittlestars	18.5	0.69			46
	2.5	0.09			
Clamys shell	21.6	0.80			94
Sea urchin	5.6	0.21		0.16	
	7.1	0.26	0.028		29
Serripes groenlandica flesh	1.79	0.066			21
Serripes groenlandica shell	3.8	0.139			91
Coral	10.2	0.38			75
	2.0	0.075			24
Sea anemone	0.61	0.023			11
Ballanus shell	4.6	0.17			78
Ballanus flesh					24
Crinoidea					50
Ascidiacea	4.0	0.15			20
Bryozo	11	0.41			16
Holothurioidea	0.71	0.026			11.6
Solaster sp.	4.6	0.09		0.44	
Shrimps total	1.75	0.065			22
	3.6	0.132			26
Worms flesh	19	0.70	0.011		22
Worms shell	40	1.49		0.18	47
	92	3.41		0.16	
Hiatella striata flesh	5.2	0.19			21
Hiatella striata shell	9.0	0.33			88
Snail eggs	9.8	0.36			14
Musculus lavigatus shell					73
Musculus lavigatus flesh	1.1	0.041			17
Astarte borealis shell	10.8	0.40			91
Astarte borealis flesh	2.0	0.075			21
Brachiopod shell	3.9	0.144			88
Astarte montagui flesh	3.6	0.133			19
Astarte montagui shell	41	1.53			86
Clinocardium flesh	1.95	0.072			17
Clinocardium shell	8.8	0.32			90
Snail flesh	1.71	0.063			27
Snail shell	8.1	0.30			

Table B.17. Plutonium and Americium in benthos collected at Thule, August 1979, at location: V 76°31'3N 69°17'4W: point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	114 133	4.2 4.9	0.017 0.012	0.17 0.21	20
Macoma shell	473 467	17.5 17.3	0.021 0.016	0.18 0.12	88
Hiatella flesh	242	9.0	0.013	0.18	20
Hiatella shell	134 147	5.0 5.4	0.027 0.019	0.27 0.34	84
Musculus flesh	18	0.67	0.026		22
Musculus shell	28	1.04			95
Brittlestars	214 245	7.9 9.1	0·013 0.018	0.084 0.109	46
Coral	911 9010	34 330	0.012 0.012	0.088 0.096	56
Worms flesh	586	22	0.017	0.13	22
Worms shell	980 1110	36 41	0.017 0.018	0.12 0.11	45

Table B.18. Plutonium and Americium in benthos collected at Thule, August 1979, at location: X 76°31'5N 69°15'8W: 0.8 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	506	18.7	0.010	0.23	21
Macoma shell	572	21	0.016	0.19	90
Hiatella flesh	53	1.96	0.025		16
Hiatella shell	327 288	12.1 10.7	0.012 0.016	0.16 0.21	90
Worms flesh	230	8.5	0.015	0.098	30

Table B.19. Plutonium and Americium in benthos collected at Thule, August 1979, at location: Y 76°31'N 69°18'5W: 0.8 km from point of impact

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Macoma flesh	386	14.3	0.015	0.17	18
Macoma shell	1290 1140	48 42	0.014 0.017	0.14 0.16	83
Musculus flesh	180	6.7	0.019		16
Musculus shell	400	15.0	0.015	0.28	77

Table B.20. Plutonium and Americium in algae collected at Thule, August 1979

Position	Unit	Species and plant part							
		Fucus total plant		Laminaria leaves		Laminaria stems		Green algae	Agarum
76°43'N 73°00'W	pCi ^{239,240}Pu kg^{-1} dry	14.6,	16.7*	3.0		3.4			
tidal zone	(Bq kg^{-1})	(0.54)	(0.62)	(0.11)		(0.13)			
98 km	^{238}Pu/^{239,240}Pu		0.051*						
	^{241}Am/^{239,240}Pu	0.043							
76°43'N 73°00'W	pCi ^{239,240}Pu kg^{-1} dry			4.8,	11.3*	4.9,	5.3*		
8 m depth	(Bq kg^{-1})			(0.25)	(0.42)	(0.18)	(0.20)		
98 km	^{238}Pu/^{239,240}Pu				0.040*				
	^{241}Am/^{239,240}Pu				0.088*	0.13			
76°34'N 68°50'W	pCi ^{239,240}Pu kg^{-1} dry	7.7,	7.6*					16.1*	
tidal zone	(Bq kg^{-1})	(0.29)	(0.28)					(0.60)	
13 km	^{238}Pu/^{239,240}Pu								
	^{241}Am/^{239,240}Pu								
76°45'N 69°55'W	pCi ^{239,240}Pu kg^{-1} dry	7.8		5.7		6.5			4.8
tidal zone	(Bq kg^{-1})	(0.29)		(0.21)		(0.24)			(0.18)
30 km	^{238}Pu/^{239,240}Pu								
	^{241}Am/^{239,240}Pu								
76°27'N 69°21'5W	pCi ^{239,240}Pu kg^{-1} dry					3.24			
5 m depth	(Bq kg^{-1})					(0.12)			
8.2 km	^{238}Pu/^{239,240}Pu								
	^{241}Am/^{239,240}Pu								
76°27'N 69°21'5W	pCi ^{239,240}Pu kg^{-1} dry			1.64		2.00			
tidal zone	(Bq kg^{-1})			(0.061)		(0.074)			
8.2 km	^{238}Pu/^{239,240}Pu								
	^{241}Am/^{239,240}Pu								

*Samples analysed by Elis Holm, Lund, Sweden.

*Collected in Power Harbour at Thule Air Base.

Table B.21. Plutonium and Americium in marine fish collected at Thule, August 1979

Sample		pCi ^{239,240}Pu kg^{-1} fresh weight	Bq ^{239,240}Pu kg^{-1}	^{238}Pu/^{239,240}Pu	^{241}Am/^{239,240}Pu	% dry matter
Sea scorpion 76°33'N 69°35'W	meat	0.043	0.0016		0.13	
	roe	B.D.L.				
	liver	B.D.L.				
	bone	0.41	0.015			
Sea scorpion 76°33'N 68°50'W	meat	B.D.L.				
	bone	B.D.L.				
Sea scorpion 76°27'N 69°21'5W	total	0.14	0.005			22
Polar cod R	total	1.74	0.065			20

Table B.22. Plutonium and Americium in marine birds collected at Thule, August 1979

Sample		pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1}	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Guillemot Maniussak	2 birds: meat	0.092	0.0034			
	*2 birds: bone	B.D.L.				
	5 birds: liver	1.5	0.054			
	3 birds: meat	B.D.L.				
	*3 birds: bone	B.D.L.				
Eider Maniussak	meat	B.D.L.				25
	bone	B.D.L.				65
	2 birds: bone	1.5	0.057		0.24	
	5 birds: liver	0.065	0.0024			29
*Guillemot bone combined		B.D.L.				

Table B.23. Plutonium and Americium in marine mammals shot at Thule in March-April 1980

Sample		pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
Seal 1 * (4/3-80) (North of Saunders Isl.)	meat	B.D.L.				
	liver	0.075	0.0028		B.D.L.	52
	kidney	B.D.L.				
	bone+	B.D.L.				57
Seal 2 * (1/3-80) (North of Saunders Isl.)	meat	B.D.L.				42
	liver¤	B.D.L.				43
	bone+	B.D.L.				70
Seal 3 * (5/4-80) (South of Saunders Isl.)	meat	B.D.L.				37
	liver¤	B.D.L.				39
	bone+	B.D.L.				70
Seal 4 * (5/4-80) (South of Saunders Isl.)	meat	B.D.L.				42
	bone+	B.D.L.				65
Whalros 1 ** (5/4-80) (West of Saunders Isl.)	meat*	B.D.L.				29
	liver$^{\Delta}$	0.028	0.0010			35
	bone$^{\nabla}$	B.D.L.				41
Whalros 2 ** (10/4-80) (West of Saunders Isl.	meat*	B.D.L.				33
	liver$^{\Delta}$	0.16±0.01	0.0059		0.65	31
	bone$^{\nabla}$	B.D.L.				49
Whalros 3 ** (15/3-80) (West of Saunders Isl.)	meat*	B.D.L.				29
	liver$^{\Delta}$	0.033	0.0012			31
	bone$^{\nabla}$	B.D.L.				67
Whalros 4 ** (10/4-80) (West of Saunders Isl.	meat*	B.D.L.				32
	liver	lost				40
	bone$^{\nabla}$	B.D.L.				49

B.D.L.: bone < 1 pCi kg^{-1} fresh weight

B.D.L.: meat < 0.1 pCi kg^{-1} fresh weight.

Measurements of combined samples:			
¤Seal liver (2*,3*)	0.0014		41
+Seal bone (1*,2*,3*,4*)	0.0022		64
Walrus flesh (1,2*,3*,4*)	0.00013		30
Seal meat (1*,2*,3*,4*)	B.D.L. (<0.0001)		
$^{\Delta}$Walrus liver (1*,2*,3*)	0.0043		32
$^{\nabla}$Walrus bone (1*,2*,3*,4*)	0.0037		59

Table B.24. Plutonium and Americium in terrestrial samples collected at Thule, August 1979

Sample	pCi $^{239,240}Pu$ kg^{-1} fresh weight	Bq $^{239,240}Pu$ kg^{-1} fresh weight	$^{238}Pu/^{239,240}Pu$	$^{241}Am/^{239,240}Pu$	% dry matter
100 l stream water Narssarssuk 76°27'W 69°21'5W	0.71 10^{-3}	0.026 10^{-3}	0.067	0.15	
Cetraria nivalis Carey Islands 76°43'W 73°00'W	13.7 16.3	0.51 0.60	0.060 0.058	0.41	31 31
Cetraria nivalis Saunders Island 1.3 m^2 $^{239,240}Pu$: 0.72 nCi m^{-2} = 26.7 Bq m^{-2}	530 590	19.6 21.9	0.016 0.017	0.12 0.11	28 28
Cetraria nivalis Narssarssuk 0.34 m^2 $^{239,240}Pu$: 2.00 nCi m^{-2} = 74 Bq m^{-2}	760 895	28.2 33.2	0.015 0.018	0.091	39 39
Saxifraga oppositifolia Saunders Island south I	57	2.11	0.020		49
Dryas octopetala Saunders Island south II	208	7.7	0.023		64

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